## REMARKS

By the present amendment and response, independent claims 1, 9, 26 and 35 have been amended to overcome the Examiner's objections. Claims 1-2, 4-9, 17-22, 26-29, and 31-37 are pending in the present application. Reconsideration and allowance of pending claims 1-2, 4-9, 17-22, 26-29, and 31-37 in view of the following remarks are requested.

Applicant acknowledges the Examiner's approval of the proposed drawing corrections submitted in the Response to the Office Action dated April 2, 2002, which was filed by Applicant on July 29, 2002. Applicant also acknowledges that, in response to Applicant's request, the Examiner has agreed to hold the requirement for submission of corrected drawings in abeyance until allowance of the present application. The Examiner has communicated his agreement by leaving a telephonic message for Applicant's undersigned attorney on April 28, 2003.

The Examiner has rejected claims 1-2, 4-9, 17-22, 26-29, and 31-37 under 35 USC §102(b) as being anticipated by U.S. patent number 5,627,402 to Hisashi Takemura ("Takemura"). For the reasons discussed below, Applicant respectfully submits that the present invention, as defined by amended independent claims 1, 9, 26 and 35, is patentably distinguishable over Takemura.

The present invention, as defined by amended independent claim 1, teaches, among other things, "selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of the varactor

device is optimized," "forming a first implant in said epitaxial layer using said first implant energy, said first implant having said first peak dopant concentration and said second conductivity type, wherein said first implant extends into said epitaxial layer a first distance," and "forming a second implant in said epitaxial layer using a second implant energy, said second implant having a second peak dopant concentration and said second conductivity type, wherein said second implant extends into said epitaxial layer a second distance, wherein said second distance is greater than said first distance." As disclosed in the present application, the present invention forms first and second implants having first and second peak dopant concentrations and first and second implant energies, respectively, in an epitaxial layer of a semiconductor substrate, where the first and second implants and the epitaxial layer each have the same conductivity type (i.e. a second conductivity type). As disclosed in the present application, by appropriately selecting the first peak dopant concentration and first implant energy of the first implant, the present invention advantageously achieves a varactor device having at least an optimized capacitance, leakage current, or tuning range.

Furthermore, as disclosed in the patent application, by appropriately selecting the second peak dopant concentration and second implant energy of the second implant, the present invention achieves a varactor having a minimized base resistance, which advantageously results in the varactor having an optimized quality factor ("Q"). Thus, by appropriately choosing the first and second peak dopant concentrations and first and second implant energies of first and second implants, respectively, the present invention

advantageously achieves a double-implant varactor that can be selectively optimized to match the specific requirements of a particular application. For example, all of the parameters, i.e. capacitance, leakage current, tuning range, and base resistance, of the present invention's varactor can be optimized by choosing the appropriate the first and second peak dopant concentrations and first and second implant energies of first and second implants, respectively. By way of further example, the above parameters of present invention's varactor could be selected for optimal leakage current and tuning range and a non-optimal base resistance.

In contrast, Takemura does not teach, disclose, or suggest "selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of the varactor device is optimized," "forming a first implant in said epitaxial layer using said first implant energy, said first implant having said first peak dopant concentration and said second conductivity type, wherein said first implant extends into said epitaxial layer a first distance," and "forming a second implant in said epitaxial layer using a second implant energy, said second implant having a second peak dopant concentration and said second conductivity type, wherein said second implant extends into said epitaxial layer a second distance, wherein said second distance is greater than said first distance." Takemura specifically discloses variable-capacitance device 10 comprising n-type epitaxial growth layer $13_1$ formed over buried $n^+$ region 12 of p-type silicon substrate 11 and n-type diffusion layer 14 formed on n-type epitaxial growth layer $13_1$. See, for example, column 3, lines 46-54 and Figure 3 of Takemura. In

Takemura, a desired capacitance of variable-capacitance device 10 is achieved by optimizing an area where p-type diffusion layer 17 and n-type diffusion layer 14 contact each other and the impurity concentration profile of n-type diffusion layer 14. See, for example, Takemura, column 5, lines 66-67 and column 6, lines 1-3.

However, Takemura does not teach, disclose, or suggest forming first and second implants in an epitaxial layer, where the first and second implants have first and second peak dopant concentrations, respectively, and where the second implant extends into the epitaxial layer a greater distance than the first implant. Furthermore, Takemura does not teach, disclose, or suggest selecting a first peak dopant concentration and implant energy such that a choice of optimizing at least one of capacitance, leakage current, and tuning range is provided. In fact, Takemura does not even mention optimizing leakage current or tuning range. Additionally, Takemura does not teach, disclose, or suggest appropriately selecting the second peak dopant concentration and second implant energy of the second implant to achieve a varactor having a minimized base resistance. For the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claim 1, is not suggested, disclosed, or taught by Takemura.

The present invention, as defined by amended independent claims 9, teaches, among other things, selecting a second peak dopant concentration and a second implant energy "with relation to said first peak dopant concentration and said first implant energy such that the base resistance of the varactor device is minimized." Also, the present invention, as defined by amended independent claim 9, teaches similar limitations and

provides similar advantages as amended independent claim 1 as discussed above. Further, the present invention, as defined by amended independent claim 26, teaches, among other things, similar limitations and provides similar advantages as amended independent claim 1 as discussed above. Moreover, the present invention, as defined by amended independent claim 35, also teaches, among other things, similar limitations and provides similar advantages as amended independent claim 1 as discussed above. As such, and based on the foregoing reasons, amended independent claims 9, 26, and 35 are patentably distinguishable over Takemura. Thus, claims 2, 4-8, and 17-19 depending from amended independent claim 1, claims 20-22 depending from amended independent claim 9, claims 27-29 and 31-34 depending from amended independent claim 26, and claims 36 and 37 depending from amended independent claim 35 are, *a fortiori*, also patentably distinguishable over Takemura for at least the reasons presented above and also for additional limitations contained in each dependent claim.

The Examiner has further rejected claims 1-2, 4-9, 17-22, 26-29, and 31-37 under 35 USC §102(b) as being anticipated by U.S. patent number 5,854,117 to Huisman et al. ("Huisman"). For the reasons discussed below, Applicant respectfully submits that the present invention, as defined by amended independent claims 1, 9, 26 and 35, is patentably distinguishable over Huisman.

In contrast to the present invention, as defined by amended independent claim 1 discussed above, Huisman specifically discloses a varicap diode having epitaxial layer 2, which includes first zone 3 comprising dopant atoms of a first conductivity and third zone

7 comprising a comparatively deep implantation of dopant atoms of the first conductivity with an implantation energy of 80 keV. See, for example, column 4, lines 34-46 and Figure 5 of Huisman. In Huisman, the dopant dose and implantation energy for formation of first zone 3 is determined by the desired frequency band of operation of the varicap diode. See, for example, Table 3 of Huisman. However, Huisman does not teach, disclose, or suggest selecting a first peak dopant concentration and implant energy such that a choice of optimizing at least one of capacitance, leakage current, and tuning range is provided. In fact, Huisman does not even discuss optimizing leakage current.

Furthermore, Huisman does not teach, disclose, or suggest implanting an epitaxial layer utilizing first and second implants having respective first and second peak dopant concentrations. In fact, in Huisman, scattering oxide 6 is grown over epitaxial layer 2 to provide a more uniform distribution of dopant atoms in subsequent implantations. See, for example, column 4, lines 41-43 and Figure 2 of Huisman. Thus, Huisman teaches away from utilizing a peak dopant concentration to optimize parameters of the varicap diode, such as capacitance, leakage current, tuning range, or resistance. For the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claim 1, is not suggest, disclosed, or taught by Huisman.

In addition to the limitations and advantages discussed above for amended independent claim 1, the present invention, as defined by amended independent claim 9 teaches, among other things, selecting a second peak dopant concentration and a second implant energy "with relation to said first peak dopant concentration and said first implant

energy such that the base resistance of the varactor device is minimized." In contrast, Huisman specifically discloses adapting the thickness of the epitaxial layer to achieve a varicap diode having a low series resistance. See, for example, Huisman, column 6, lines 48-50. However, Huisman does not teach, disclose, or suggest utilizing an implant having a peak dopant concentration and implant energy to reduce the resistance of the varicap diode.

Further, the present invention, as defined by amended independent claim 26, teaches, among other things, similar limitations and provides similar advantages as amended independent claim 1 as discussed above. Moreover, the present invention, as defined by amended independent claim 35, also teaches, among other things, similar limitations and provides similar advantages as amended independent claim 9 as discussed above. As such, and based on the foregoing reasons, amended independent claims 9, 26, and 35 are patentably distinguishable over Huisman. Thus, claims 2, 4-8, and 17-19 depending from amended independent claim 1, claims 20-22 depending from amended independent claim 9, claims 27-29 and 31-34 depending from amended independent claim 26, and claims 36 and 37 depending from amended independent claim 35 are, *a fortiori*, also patentably distinguishable over Huisman for at least the reasons presented above and also for additional limitations contained in each dependent claim.

Based on the foregoing reasons, the present invention, as defined by amended independent claims 1, 9, 26, and 35, and claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 1-2, 4-9, 17-22, 26-29, and 31-37 pending in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early allowance of claims 1-2, 4-9, 17-22, 26-29, and 31-37 pending in the present application is respectfully requested.

Respectfully Submitted,
FARJAMI & FARJAMI LLP

Michael Farjami, Esq.
Reg. No. 38, 135

Date: 5/2/03

Michael Farjami, Esq.
FARJAMI & FARJAMI LLP
16148 Sand Canyon
Irvine, California 92618
Telephone: (949) 784-4600
Facsimile: (949) 784-4601

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

**In the Claims:**

**Claims 1, 9, 26, and 35 have been amended as follows:**

1. (Twice Amended) A method of forming a varactor device on a semiconductor substrate, comprising the steps of:

providing [a] an epitaxial layer situated in said semiconductor substrate, said semiconductor substrate having a first conductivity type and said epitaxial layer having a second conductivity type;

providing an isolation structure on said semiconductor substrate, said isolation structure defining an implant region, said implant region being situated over said epitaxial layer;

selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of the varactor device is optimized;

forming a first implant in said [implant region of said isolation structure] epitaxial layer using said first implant energy, said first implant having said first peak dopant concentration and [a] said second conductivity type, wherein said first implant extends into [the implant region] said epitaxial layer a first distance;

forming a second implant in said [implant region of said isolation structure] epitaxial layer using a second implant energy, said second implant having a second peak dopant concentration and said second conductivity type, wherein said second implant extends into [the implant region] said epitaxial layer a second distance, wherein said second distance is greater than said first distance.

9. (Once Amended) A method of forming a varactor device on a semiconductor substrate, comprising the steps of:

providing [a] an epitaxial layer situated in said semiconductor substrate, said semiconductor substrate having a first conductivity type and said epitaxial layer having a second conductivity type;

providing an isolation structure on said semiconductor substrate, said isolation structure defining an implant region, said implant region being situated over said epitaxial layer;

forming a first implant in said [implant region of said isolation structure] epitaxial layer using a first implant energy, said first implant having a first peak dopant concentration and [a] said second conductivity type, wherein said first implant extends into [the implant region] said epitaxial layer a first distance;

forming a second implant in said implant region of said isolation structure using a second implant energy, said second implant having a second peak dopant concentration

and said second conductivity type, wherein said second implant extends into [the implant region] said epitaxial layer a second distance,

wherein said second distance is greater than said first distance, wherein said first peak dopant concentration and said first implant energy are selected such that at least one of capacitance, leakage current, and tuning range of the varactor device are optimized, and wherein said second peak dopant concentration and said second implant energy are selected with relation to said first peak dopant concentration and said first implant energy such that the base resistance of the varactor device is minimized.

26. (Twice Amended) A method of forming a varactor device on a semiconductor substrate, comprising steps of:

providing [a] an epitaxial layer situated in said semiconductor substrate, said semiconductor substrate having a first conductivity type and said epitaxial layer having a second conductivity type;

selecting a first peak dopant concentration and first implant energy such that at least one of capacitance, leakage current, and tuning range of the varactor device is optimized;

forming a first implant in [at least a portion of said semiconductor substrate] said epitaxial layer using said first implant energy, said first implant having said first peak dopant concentration and a second conductivity type, wherein said first implant extends into said [semiconductor substrate] epitaxial layer a first distance;

forming a second implant in [at least a portion of said semiconductor substrate] said epitaxial layer using a second implant energy, said second implant having a second peak dopant concentration and said second conductivity type, wherein said second implant extends into said [semiconductor substrate] epitaxial layer a second distance, wherein said second distance is greater than said first distance.

35. (Once Amended) A method of forming a varactor device on a semiconductor substrate, comprising the steps of:

providing [a] an epitaxial layer situated in said semiconductor substrate, said semiconductor substrate having a first conductivity type and said epitaxial layer having a second conductivity type;

forming a first implant in [at least a portion of said semiconductor substrate] said epitaxial layer using a first implant energy, said first implant having a first peak dopant concentration and a second conductivity type, wherein said first implant extends into said [semiconductor substrate] epitaxial layer a first distance;

forming a second implant in [at least a portion of said semiconductor substrate] said epitaxial layer using a second implant energy, said second implant having a second peak dopant concentration and said second conductivity type,

wherein said second distance is greater than said first distance, wherein said first peak dopant concentration and said first implant energy are selected such that at least one of capacitance, leakage current, and tuning range of the varactor device are optimized, and wherein said second peak dopant concentration and said second implant energy are selected with relation to said first peak dopant concentration and said first implant energy such that the base resistance of the varactor device is minimized.